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Geographic range extension of the Spix's Disk-winged Bat, *Thyroptera tricolor* Spix, 1823 (Chiroptera, Thyropteridae)—first record from Santa Catarina, southern Brazil

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Abstract. We captured the Spix's Disk-winged Bat, *Thyroptera tricolor* Spix, 1823, at two locations in Santa Catarina state, southern Brazil. These are the first records of occurrence of *T. tricolor* from the state and expand the southern limit of the species' geographical range by 408 km. With our new data, 52 species of bat are now confirmed to occur in Santa Catarina; this state has the second richest bat fauna in southern Brazil.

Keywords. Atlantic Forest, distribution, bats, mist nets, Parque das Nascentes, São Francisco Reserve

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Introduction

Species of the bat family Thyropteridae occur in moist, lowland, Neotropical forests from Mexico to southeastern Brazil (Lee 2019). Members of this family are easily distinguished from other Neotropical bats by the presence of adhesive disks on the soles of their feet and on their thumbs (Boada et al. 2010; Lee 2019). They are small bats with an average weight of 4 g and have funnel-shaped ears, a long snout, rounded nostrils, and small eyes (Findley and Wilson 1974; Wilson 2008; Chaverri and Vonhof 2011; Semedo et al. 2020). Thyropteridae is represented by a single genus, *Thyroptera* Spix, 1823, and five species, *Thyroptera tricolor* Spix, 1823, *Thyroptera discifera* (Lichtenstein & Peters, 1854), *Thyroptera lavali* Pine, 1993, *Thyroptera devivoi* Gregorin, Gonçalves, Lim & Engstrom 2006, and *Thyroptera wynneae* Velazco, Gregorin, Voss & Simmons, 2014 (Wilson 2008; Velazco et al. 2014), all with confirmed records in Brazil (Garbino et al. 2022). In the Atlantic Forest, only *T. wynneae* and *T. tricolor* have been confirmed (Hoppe et al. 2014; Solari 2015, 2016; Solari and Velazco 2016; Tavares and Mantilla 2016; Solari and Villada-Cadavid 2018).

Thyroptera tricolor is distributed from southern Mexico, through Central America, northern and western South America, to the northern region and the coast of Brazil (Wilson 2008; Tavares and Mantilla 2016; Lee 2019). It occurs at elevations up to 1,800 m above sea level (Reyes-Amaya et al. 2016). The southernmost dis-

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tribution limit of this species is the southern Brazilian state of Paraná (Passos et al. 2010). *Thyroptera tricolor* is as a small-bodied species having an average weight of 4 g and a forearm length of 35.9 mm, and females are larger than males (Chaverri and Vonhof 2011). This species has a slow and maneuverable flight, and flies 3–5 m above the ground, which results in a low rate of capture in mist nets in the understory (Findley and Wilson 1974; Castaño-Salazar et al. 2004; Esbérard et al. 2007; Boada et al. 2010; Garbino 2016). Manual captures in roosts (Velazco et al. 2014) have shown that over 100 individuals are present in a single site (e.g. Vonhof and Fenton 2004; Chaverri 2010; Chaverri and Vonhoff 2011; Sagot et al. 2022).

Due to its ability to adhere to and move on smooth surfaces, *T. tricolor* roosts in the young leaves of genera *Heliconia* L., *Musa* L., and occasionally *Calathea* G. Mey. and *Cecropia* Loefl. (Findley and Wilson 1974; Vonhof and Fenton 2004; Velazco et al. 2014). Bats of this species form cohesive groups in shelters with strong social relationships and composed of up to 11 individuals, which are possibly related; bats roost in rows, positioned with their heads facing upwards (Findley and Wilson 1974; Vonhof and Fenton 2004; Vonhof et al. 2004; Chaverri 2010).

Throughout the geographic range of *T. tricolor*, the species is usually recorded within protected areas (Dechmann et al. 2006; Passos et al. 2010; Chaverri 2010; Chaverri and Kunz 2011; Montero and Gillam 2015). However, it can also be found less frequently in degraded or human-modified landscapes, such as rubber-tree plantations and small forest fragments (Castaño-Salazar et al. 2004; Esbérard et al. 2007; Boada et al. 2010). Although sensitive to environmental changes, *T. tricolor* is currently classified as Least Concern according to IUCN Red List criteria (Tavares and Mantilla 2016), and it is not on the Official List of Endangered Species of the Brazilian Fauna (MMA 2022). Here, we present an geographic range extension of *T. tricolor* and the first record from Santa Catarina based on newly collected specimens at localities within the Atlantic Forest.

Methods

Our new records of *T. tricolor* were obtained at two localities in the state of Santa Catarina (Fig. 1), both in Dense Ombrophilous Forest inserted in the Atlantic Forest phytogeographic domain (IBGE 2012). According to the Köeppen climate classification system, the predominant climate in both locations is the *Cfa* type, which is characterized as humid subtropical with hot summers and no defined dry season (Alvares et al. 2013).

The first location was in the Nascentes do Garcia Municipal Natural Park in the city of Blumenau, northern Santa Catarina (Fig. 1). The park has an area of approximately 53 km^2 and is within the area of the Serra do Itajaí National Park, and as a result, the park integrates a large and continuous forest remnant, which extends beyond its boundary and forms an important ecological corridor between conservation units on the slopes of Serra Geral. The second location was in the São Francisco Natural Reserve in the city of Nova Veneza, in southernmost Santa Catarina (Fig. 1). Currently, the reserve has an area of approximately 15 km^2 and is connected to the Aguaí State Biological Reserve, an important protected area in Santa Catarina. On a macro scale, considering the landscape matrix, the two locations are connected by the Serra Geral ecological corridor.

In the Nascente do Garcia Municipal Park the bat was captured inside a house, located on the edges of a forest remnant. In São Francisco Natural Reserve the capture occurred during sampling for a research project on the bat fauna. In this area, sampling began in April 2022, with three sampling nights in each month. For each sampling night, 10 mist nets (two of 12 m × 2.6 m, four of 9 × 2.6 m, and four of 6 × 2.6 m) were installed and remained open for 6 h after sunset. The nets were placed on trails, forest edges, over bodies of water, and in banana plantations.

Two captured individuals were collected, fixed and preserved in 70% alcohol and had their skull prepared and deposited in the Zoology collection of the Regional University of Blumenau (CZFUB-SLA) and in the collection of the Zoology Laboratory of the University of the Extreme South of Santa Catarina (LABZEV). We measured one specimen (LABZEV 1007) using calipers (to the nearest 0.001 mm), measuring forearm length, condyloincisive length, maxillary toothrow length, mandibular toothrow length, length of mandible, greatest length of skull, braincase breadth, zygomatic breadth, width at M3, postorbital breadth, and rostral length.

Results

Materials examined. BRAZIL – **Santa Catarina** • Blumenau, Nascentes do Garcia Municipal Natural Park; 27°03′16″S, 049°05′07″W; 301 m alt.; 07.XI.2004; A.S. Sobrinho & S.L Althoff leg.; inside a residence next to a forest remnant/manual capture; 1 ♂, CZFUB-SLA 2700 • Nova Veneza, São Francisco Reserve; 28°39′10″S, 049°37′52″W; 207 m alt.; 24.VIII.2022; F. Carvalho & V. Quintas leg; using a polyester mist net (Ecotone®), installed in the midst of a banana plantation; 1 ♂, LABZEV 1007.

Identification. The specimens were identified based on morphological characters described by Miranda et al. (2011), Velazco et al. (2014), and Díaz et al. (2016); the following diagnostic morphological traits were observed: (1) circular disks on the thumbs; (2) forearm length 32–39mm; (3) white or yellowish ventral pelage which contrasts with the dorsal pelage; (4) proximal portion of the forearm sparsely haired; (5) dark ears; (6) calcar with two lappets posteriorly (Fig. 2, Table 1). The morphological data indicates that, of the 11 analyzed measurements, the individual from the São Francisco Reserve (LABZEV 1007) was larger in six

Figure 1. Distribution map of *Thyroptera tricolor* in Central and South America with addition of new records in state of Santa Catarina, where: Garcia Municipal Natural Park - PNMNG and, São Francisco Natural Reserve – RNSF.

Table 1. Measurements of the external and cranial morphological characters (in mm) of the individual captured in the São Francisco Reserve, in the south of Santa Catarina (LABZEV 1007), and those presented by Velazco et al. (2014), Passos et al. (2010) and Lee (2019).

Characters	**Present study**	**Passos et al. (2010)**	**Velazco et al. (2014)**		**Lee (2019)***
	LABZEV 1007 ♂	♂	♀	♂	♂, ♀
Forearm length	35.98	34.35	37.10	36.70	—
Condyloincisive length	14.27	14.05	13.70	13.50	12.90–14.40
Maxillary toothrow length	6.68	6.05	5.90	5.90	5.50–6.30
Mandibular toothrow length	6.39	6.10	6.20	6.10	—
Length of mandible	11.04	10.50	10.60	10.40	—
Greatest length of skull	15.67	15.45	14.60	14.30	13.60–15.70
Braincase breadth	7.62	7.80	7.30	7.30	—
Zygomatic breadth	7.94	7.80	7.50	7.40	6.90–7.70
Width at M3	5.39	—	5.20	5.20	—
Postorbital breadth	2.98	2.85	2.70	2.70	—
Rostral length	5.45	—	5.30	—	5.30–5.50

*The range shown represents the minimums and maximums observed in Lee's (2009) study.

measurements (mandibular and maxillary toothrow length, length of mandible, zygomatic breadth, width at M3 and postorbital breadth: Table 1) than compared to those from other locations.

Discussion

The records that we provide here represent the first two confirmed localities of *T. tricolor* in Santa Catarina; this

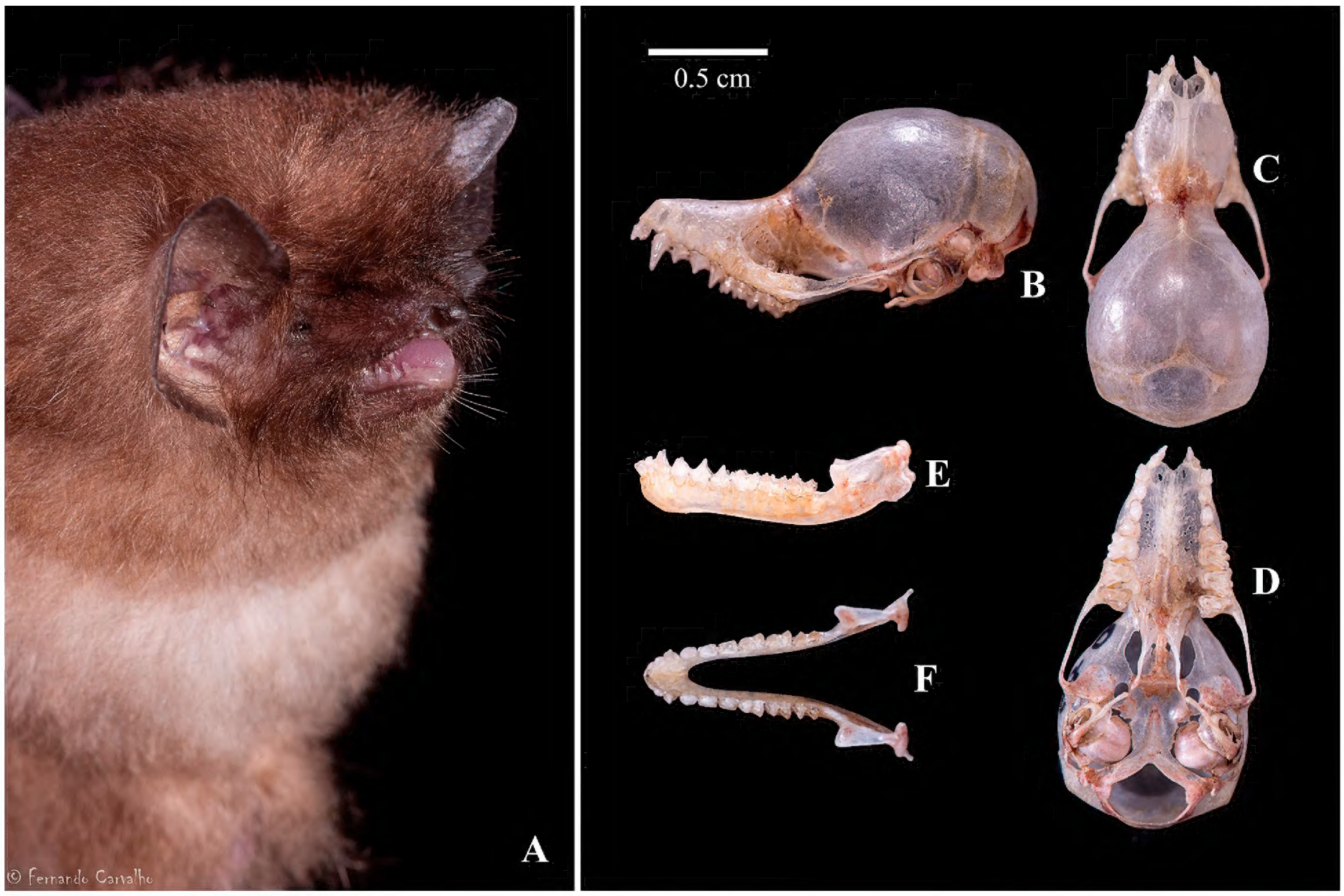

Figure 2. *Thyroptera tricolor* captured in the São Francisco Reserve. **A.** Specimen. **B–D.** Skull, in lateral, dorsal, and ventral view, respectively. **E, F.** Mandible, in lateral view and dorsal view. Scale bars: 0.5 cm.

species had not been reported from the state until now (e.g. Cherem et al. 2004; Pacheco et al. 2007; Passos et al. 2010; Carvalho et al. 2013; Bôlla et al. 2017). Additionally, the São Francisco Reserve record extends the species' known southern distributional limit by 408 km from the Natural Patrimony Private Reserve Salto Morato, which is on the north coast of Paraná (Passos et al. 2010). Our new records of *T. tricolor* from Santa Catarina aid in understanding the distribution patterns of *T. tricolor* in the Atlantic Forest—the Atlantic Forest phytogeographic domain has few records of this species (Esbérard et al. 2007; Passos et al. 2010; Garbino 2016). This is due to the species' low rate of capture in mist nets installed in the understory (Castaño-Salazar et al. 2004; Velazco et al. 2014). In areas where other sampling methods were used, the number of captures of *T. tricolor* is higher, with more than 100 individuals detected (e.g. Chaverri 2010; Chaverri and Vonhof 2011; Sagot et al. 2022). Thus, there are large gaps in knowledge about the distribution of *T. tricolor*, and new data, such as those presented here, have importance, especially for the southern portion of the Atlantic Forest.

Both locations where we found *T. tricolor* in Santa Catarina are protected areas, and these are part of larger, conserved forest remnant. The occurrence of this species in intact forest environments has already been reported in other countries (e.g. Findley and Wilson 1974; Chaverri 2010; Chaverri and Vonhof 2011; Turcio-Casco and Medina-Fitoria 2018) and in Brazil (Sampaio et al. 2003; Bernard and Fenton 2007; Passos et al. 2010; Tavares et al. 2017; Semedo et al. 2020). *Thyroptera tricolor* has an expressive dependence on plants suitable for roosting, such as those of the genera *Heliconia* and *Calathea* (Findley and Wilson, 1974; Vonhof and Fenton 2004), which are characteristically found in the understory (Chaverri 2010; Velazco et al. 2014) of intact tropical forests. However, the Nascentes do Garcia Park individual was located inside a residence, while the São Francisco Reserve specimen was caught in a banana plantation.

In areas where preferred plants are absent, *T. tricolor* may use other plant species for shelter (Chaverri and Kunz 2011) or even roost in cavities (Esbérard et al. 2007) and man-made structures, as reported here. This suggests that the species may also be tolerant to moderately impacted or modified environments. However, in the Atlantic Forest, the environmental change has been great and may have drastically reduced the availability of shelter sites for *T. tricolor*. Bats that use ephemeral roosts, such as this species, tend to need multiple roost sites (Vonhof and Fenton 2004). Thus, the loss of shelter sites may affect the occurrence of this species, as well as the behavior and social cohesion of groups (e.g. Chaverri 2010; Chaverri and Kunz 2011), as *T. tricolor* displays extremely well-developed social behavior (e.g. Vonhof et al. 2004; Sagot et al. 2022).

The morphological measurements of the specimen captured in the São Francisco reserve are more similar to those reported by Passos et al. (2010) for an individual captured in southern Brazil than compared to

individuals captured at further south (Table 1). The reason for this is not known, and few individuals have been captured in these southern areas. However, it may be important for guiding further research.

With our new records of *T. tricolor*, 52 bat species are confirmed from Santa Catarina; at least six species have been added in the last 11 years (Passos et al. 2010; Carvalho and Fábian 2011; Cherem and Althoff 2015; Carvalho et al. 2017; Althoff et al. 2017, 2018). This is reflective of increased research groups and funding of science by government agencies, such as, for example, the Foundation for the Support of Research and Innovation of Santa Catarina (FAPESC). Despite the progress made in recent years, there is still much more to learn about the bat fauna of Santa Catarina, and the continuity of projects and funding is of fundamental importance for a better understanding of the patterns of diversity and occurrence of bat species in the state.

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Author Contributions

Conceptualization: FC, BFLL, ASS, SG, VQ, KPS, SLA. Data curation: FC, VQ. Formal analysis: FC, BFLL, ASS, SG, VQ, KPS, SLA. Funding acquisition: FC. Investigation: FC, BFLL, ASS, SG, VQ, KPS, SLA. Methodology: FC, BFLL, ASS, SG, VQ, KPS, SLA. Resources: FC, BFLL, ASS, SG, VQ, KPS, SLA. Supervision: FC, BFLL, ASS, SG, VQ, KPS, SLA. Visualization: FC, BFLL, ASS, SG, VQ, KPS, SLA. Project administration: FC. Validation: FC, BFLL, ASS, SG, VQ, KPS, SLA. Visualization: FC. Writing – original draft: FC, BFLL, ASS, SG, VQ, KPS, SLA. Writing – review and editing: FC, BFLL, ASS, SG, VQ, KPS, SLA.

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